Indicators Working Group

- Definition: Ecosystem indicators are metrics that tell us something about an ecosystem.
- There are several "taxonomies" of indicators; we loosely group them into two classes:
  - *Status indicators* tell us something about the condition of an ecosystem (i.e., "where we are").
  - *Management indicators* tell us something about how potential management actions might affect the condition of an ecosystem (i.e., assess action/response scenarios that might move us to where we want to be").

Key Aspects of Indicators

- Measures an ecosystem characteristic or process that we are interested in, which may be stated by a stakeholder group or legislatively mandated;
- Values change directionally in association with the direction of change in that characteristic or process;
- Convenient to measure and calculate using available data;
- Easy to communicate, recognizing that different audiences (e.g., decision makers, interest groups, educational groups) may require different indicators.

What is the current state of the art in this discipline?

- The use of indicators is growing in marine EBFM/EAM.
- Stronger on the biological aspects and weaker on socioeconomic aspects.
- Lists of indicators covering multiple aspects of EAM have been assembled.
- Correlation-type relationships (without mechanisms) may be useful in determining state (i.e., status indicators).
- Indicators should not be treated as “performance targets” for management (management indicators) without direct mechanistic linkages.

Indicator Selection

- Broad stakeholder involvement in selecting and identifying indicators improves their use/acceptance later on in the management process.
- General protocols exist for the selection of desirable indicators for EAF/EBFM (see refs).
- Most examples of selected indicators fall into 5-7 main categories (see refs), which we recommend/endorse.
- General protocols exist for the grouping, combining, and integrated examination of multiple indicators.

Indicators & Decision Criteria

- Most indicators are not yet usable as reference points.
- Empirical use of state indicators (e.g. biomass) as a function (or partial function) of pressure indicators (e.g. fishing rate) can help establish specified thresholds or Limit Reference Points.
- Development of empirically based indicator thresholds needs further development, but can be used ***NOW*** to establish some intermediate decision criteria.

Indicators & Models

- Global examples of modeling efforts have matched empirically derived results of indicator thresholds and sensitivity.
- Most current indicators are derived from theory and/or models; indicators are predictive only if they are tied to mechanistic models.
- Mechanistic models linking an indicator to true quantities of interest are required to use an indicator as a Decision Criterion.
- Indicators tied to models with non-linear relationships to pressures may give us an intuitive sense that we are approaching a point of no return, but it may be difficult to measure position of the indicator.
- Linear indicators show trends and can allow smooth tradeoffs, but may not be a realistic measure of non-linear relationships.

Appropriate Experiences

- ACADEMIC EXAMPLES
  - Theoretical properties and steps to developing indicators have been developed.
  - Long lists of indicators have been developed and debated. There is some convergence in biological indicators.
  - Experience has shown that vetting and review of indicators is needed, including scale, aggregation, determining expected “natural” variance vs. trends, signal/noise, etc.

Operational Examples

- INFORMATIONAL TO THE PUBLIC (may have indirect policy or budget implications)
  - Examples of "state of the environment" reports for public (not necessarily decision-making) audiences.
  - **NMFS's *Our Living Oceans*** reports on status of living resources (primary indicator is stock status with respect to MSY) and on the status of habitat (primary indicators are habitat use and data quality).
  - **NMFS's *Report to Congress*** on the status of fish stocks (primary indicators are overfished and overfishing).
  - **EPA's Coastal Condition Report** (primary indicators are red/yellow/green lights for several environmental characteristics, such as dissolved oxygen and Secchi depth).

Informational with Management Implications

- Indicators used in NEPA-type analyses for fishery management plans (including informing cumulative impacts analysis).
- Alaska Ecosystem Considerations presented to council each year, includes metrics for indicators.
- Climate-type indicators incorporated into single-species assessment (affect reference point calculations without explicitly setting them) (e.g., California sardines, Bering Sea pollock, Bering Sea flatfish).
- Ecosystem Assessments ("What regime/PCA region are we in?" "What's our behavior in proportion to regime?").

Ecosystem-Related Examples

- NOAA relies heavily on performance measures as indicators of program success in the processes of strategic planning and budgeting, including for the NOAA Ecosystem Goal Team.
  - NOAA Strategic Plan.
  - NMFS Strategic Plan.
  - NOAA budget process (PPBES) – The performance measure for the NMFS Expand Stock Assessments budget line is "Reduce the number of major fish stocks with unknown status," tracked quarterly and annually.

Needs:

- Communication/Input
  - There needs to be a formal and rigorous process to determine what we (the stakeholders) care about, especially with "emergent" indicators.
  - Most indicators this group has worked with deal with EBFM, not EAM. Effort is needed to expand the inputs and associations among the EBFM indicators, as well as to tie the EBFM indicators into the broader context of EAM.
  - Necessary improvements include simplification in communication. Further development from formal "communication science" would be helpful.

Data/Research Needs

- Social and cultural indicators are not well-represented.
- Lower trophic level and forage fish indicators are missing. Input from physical models and hindcasts for plankton production would be valuable.
- The understanding of some fisheries indicators response to fishing is reasonable, but understanding of impacts of other human or natural factors is limited.
- Most aggregate indicators measure ecosystem-level states (e.g., biomass of a system) rather than pressures (e.g., global 'F' or nutrient input or rate of habitat loss) needed for mechanistic links.
- Laundry list reduction of dimensionality without removal of information can be a useful approach for further exploration. (This may be approached statistically, e.g., through reference directions/surfaces, or graphically).
- Indicators should be examined experimentally (e.g., in designing MPAs). Metaanalysis/historical analysis is another useful approach.
- Analysis of signal/noise and variance needs further work.

Policy, Governance, Science Administration Changes

- Indicators can only be an effective tool if there is an appropriate governance structure in place that can respond to them. Indicators are currently coming from the scientists, as a bottom-up process.

- Indicators should be part of developing a more integrated process of "what's important" coming from stakeholders, going to science, going to decision makers. An adaptive approach to indicators can be taken between management and science, both within the fisheries sector and, most importantly, within the larger realm of ecosystem management.

- Indicators could be a vehicle for improving communication between sectors, and even between jurisdictions within sectors.